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EFFECT OF TIME OF NITROGEN APPLICATION ON GROWTH AND PRODUCTIVITY OF SWEET LIME *(CITRUS LIMETTIOIDES* TANAKA)

Muhammad Ibrahim Chaudhry & Farrakh Naveed
Department of Horticulture,
University of Agriculture, Faisalabad

Nitrogen at the rates of 0.5, 1.0 and 1.5 kg tree^{-1} was applied to sweet lime trees, a frequently reported shy bearing citrus cultivar. Time of nitrogen application for each dose was changed from general recommended practices to two different sets of time i.e. September + October and September + February. Nitrogen at higher levels applied during September + February (fall + spring) produced and helped to retain significantly more number of leaves during winter, induced more hermaphrodite bloom, produced more yield than the treatment applied during fall only.

INTRODUCTION

The problem of poor fruiting still stands despite several research studies. The disorder is believed to be related with the production of predominant number of staminate among few hermaphrodite flowers. However, poor initial fruit set and later on heavy fruit-drop has further added to the intricacy of the problem. This problem may be attributed to improper nutrition. In pursuance of the former observations that nitrogen stimulated growth and enhanced fruitfulness of some poorly bearing citrus trees, this experiment was designed. Hayes (1960) reported that citrus plants, deficient in either nitrogen or carbohydrates, were weak in growth and were unfruitful. Lenz (1966) observed that leafy inflorescences particularly under the higher nitrogen treatments set heavier fruit in Valencia late sweet orange trees. While in nitrogen deficient trees more of the reporoductive organs dropped suddenly and were found unproductive. Jones and Embleton (1967) studied the effect of differential nitrogen fertilization on mature "Washington Navel" oranges and found significant reduction in yield per tree in control. Chaudhry (1988) noted that the new spring flushes were almost completely barren in sweet lime unlike other citrus fruits, while the flushes carrying mature healthy leaves of 5-6 months bore maximum hermaphrodite flowers and in turn bore more fruit. He further suggested that fall nitrogen application @ 1 kg tree^{-1} was superior to spring application for growth and fruit production in sweet lime.

MATERIALS AND METHODS

The research studies in sweet lime to improve fruitfulness were conducted during the year 1987-88. Nitrogen as urea was applied in three different doses. The detail of the six nitrogen treatments is as follows:

To assess the effect of of various treatments on growth and productivity, the study was carried out on the following parameters.

1.	N_1T_1	= 0.5 kg N tree^{-1} in September + October (Fall)	1987
2.	N_2T_1	= 1.0 kg N tree^{-1} in September + October (Fall)	"
3.	N_2T_1	= 1.5 kg N tree^{-1} in September + October (Fall)	"
4.	N_1T_2	= 0.5 kg N tree^{-1} in September + February (Fall + Spring)	1988
5.	N_2T_2	= 1.0 kg N tree^{-1} in September + February (Fall + Spring)	"
6.	N_3T_2	= 1.5 kg N tree^{-1} in September + February (Fall + Spring)	"

a. Growth records

Number of leaves emerged: Twenty flushes month^{-1} tree^{-1} were tagged starting from February, 1987 to record growth. The vigour of growth was recorded by simple counting of the number of leaves emerged on the selected flushes. Number of leaves dropped were also counted on these selected flushes. The final count was conducted in December, 1987.

Number of leaves retained: Number of leaves were counted again in March 1988 to note the effect of winter injury in terms of leaf fall. This count was simply made of the retained leaves on 20 flushes selected each month previously.

b. Flowering and fruiting records:

The flushes previously selected and tagged were observed for the number of male and hermaphrodite flowers, fruit set, fruit drop and fruit matured, to determine the fruiting habit in relation to nitrogen nutrition and change in pattern of growth. For count of flowers, ten flushes were selected out of the previously tagged 20 flushes each month. These were covered with perforated polyethylene bags in the beginning of the first week of March 1988 when the flushes just started blooming. Buds and flowers dropped remained stored in these bags. It minimised the chance of loss of bloom and guaranteed the accurate data on bloom. Bags were removed on completion of fruit setting by mid of April 1988. The data were generated regarding: number of blossoms borne; number of hermaphrodite flowers; number of fruit set and number of fruit matured (yield).

The experiment was laid out in randomised complete block design with factorial arrangements in two replications. The results were statistically analysed for inferences.

RESULTS AND DISCUSSION

Effect on growth: Effect of nitrogen application on leaf production and retention was diverse as the time of N application was changed (Fig. 1). Nitrogen rates of 0.5, 1.0 and 1.5 kg tree^{-1} during September + February (T_2) produced 8.2, 9.6 and 10.0 mean number of leaves per flush, respectively showing a significant effect. As a result of nitrogen doses applied during fall (T_1), the number of leaves produced flush^{-1} were 8.8, 8.6 and 8.4, respectively which were statistically at par. Thus nitrogen had a positive effect on leaf production when splitted during fall + spring (Fig. 1) but no clear response was observed for fall-application. Putcha and Prasad (1980) obtained the greatest increase in shoot length and number at the highest N level in citrus, which partially supports the present findings.

Fall applications of N increased leaf retention gradually as the dose increased. It retained 5.05, 5.30 and 5.75 leaves flush^{-1}, respectively. While least effective treatment (N_1T_2) retained only 4.84 leaves flush^{-1}. The best treatment for leaf retention, however,

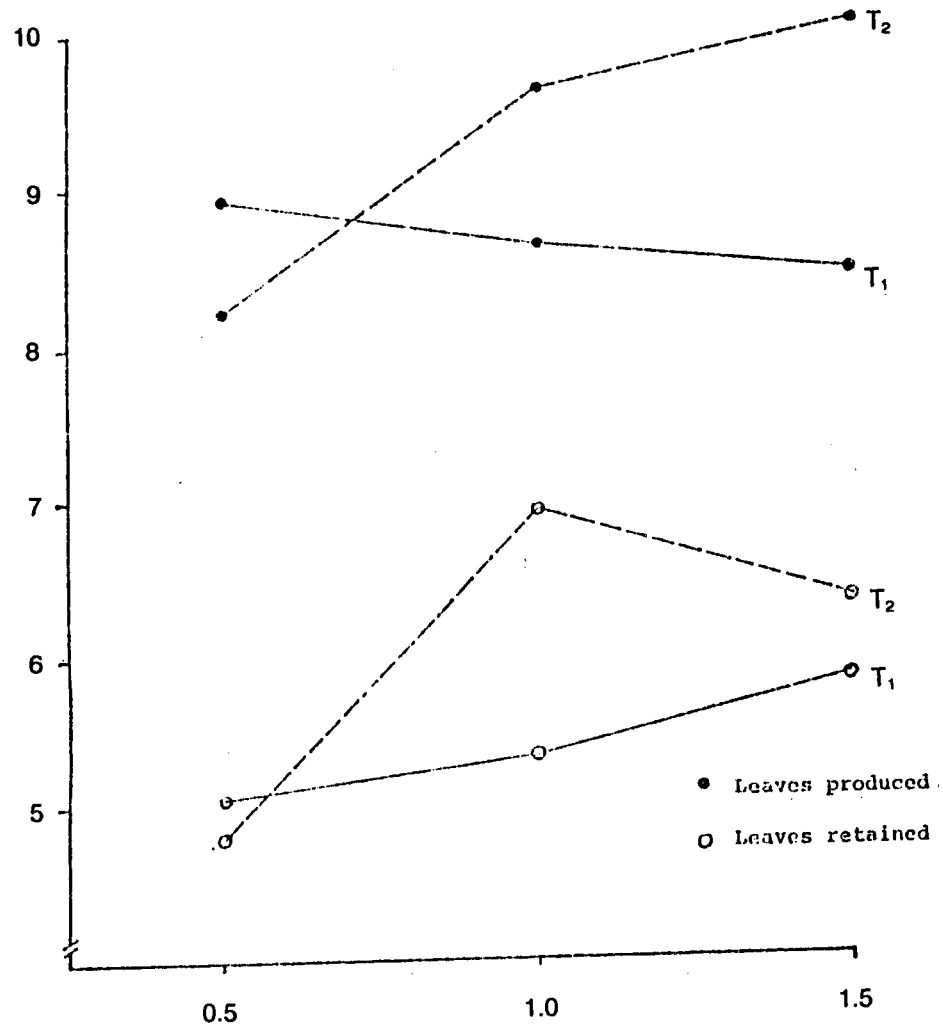

Fig. 1. Effect of nitrogen on production and retention of leaves in sweet lime.

was 1 kg nitrogen splitted in September + February which retained 6.32 leaves, followed by 1.5 kg N applied on either time as T_1 or T_2. Hayes (1960) observed similar results in citrus plants. Fall-application contributed more for retention of leaves than induction of new growth. Chaudhry (1988) reported that fall application although did not affect leaf production but it did enhance leaf retention during winter which corroborates the recent findings.

Effect on blooming: Total bloom increased with increasing nitrogen dose in September + February (Table 1). Nitrogen @ 1.5 kg $tree^{-1}$ produced the highest total bloom followed by the same dose applied during fall. A direct relation of nitrogen to both growth and flowering was established in the present study which is in close conformity with the previous research studies of Hayes (1960) in oranges and Chaudhry (1988) in sweet lime.

Table 1. Effect of nitrogen on flowering and fruiting in sweet lime

	T1			T2		
	September + October			September + February		
	0.5 kg N	1.0 kg N	1.5 kg N	0.5 kg N	1.0 kg N	1.5 kg N
Total bloom (No.)	209.7 bc	196.4 de	214.1 b	191.6 e	202.4 cd	263.6 a
Perfect flower (No.)	8.9 b	7.1 cd	7.9 c	6.2 d	6.8 d	12.4 a
Fruit set (No.)	2.9 de	2.3 cd	2.8 b	2.7 e	2.6 bc	3.4 a
Fruit matured (No.)	0.54 b	0.7 b	0.7 b	0.7 b	1.2 ab	1.6 a
Fruit drop (%)	76.3 a	75.5 a	77.9 a	57.0 b	57.2 b	45.5 c

Means sharing same letter(s) do not differ significantly at 5% level.

The results also showed that lower N doses, particularly when splitted for September + February failed to induce perfect flowering. A good flower ratio was achieved when whole of the 1 kg N was applied in fall. However, a significantly highest number of hermaphrodites appeared when the highest dose of nitrogen (1.5 kg tree^{-1}) was splitted during fall spring. Chaudhry (1988) obtained significantly the highest number of perfect flowers at the highest N level (1 kg tree^{-1}) applied during fall, while present findings indicated better perfect bloom at highest N dose (1.5 kg tree^{-1}) when splitted during fall-spring. Arkle and Nakasone (1984) claimed higher maleness at low nitrogen level in papaya.

Nitrogen applied at the highest level during September-October set significantly the highest number of fruits than any other nitrogen rate (Table 1). There was higher fruit set in this treatment than that with rest of the treatments. Fruit set (0.9%) was the poorest at the lowest N level applied either as T_1 or T_2. Previous studies of Lenz (1966), Putcha and Prasad (1980), Chaudhry (1988) reported effect of nitrogen on fruit set in various citrus cultivars.

Effect of fruit yield: Nitrogen applied in September + February (T_2) produced more fruits than that for the September + October (T_1)-application regardless of the N level (Table 1). The lowest number of fruits were matured by the lowest N level. However, any nitrogen dose applied in fall alone did not influence yield increment and thus all the doses were statistically at par. Even the lowest N (T_2) was also statistically at par with the yield obtained by the highest N application as T_1. Appropriate increase in yield was obtained with increasing nitrogen rates. Thus significantly highest fruit yield was obtained by the highest N level applied during fall-spring. Similar results with increasing doses towards yield increment were previously observed by Jones and Embleton (1967) in orange but Chaudhry (1988) concluded that only higher N dose could enhance yield when applied in fall.

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